Water management in Ontario

Ontario
Water Resources
Commission

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Mr. R.D. Johnson,
Chairman
Ontario Water Resources Commission,
135 St. Clair Avenue West,
Toronto, Ontario

August 17/71

Dear Sir:

The enclosed report 'Water Quality Evaluation of Sturgeon Lake, Districts of Kenora and Thunder Bay, 1970' outlines the results of a biological and water quality evaluation carried out on Sturgeon Lake prior to the commencement of base-metal mining and milling operations by Mattabi Mines Limited at their Sturgeon Lake property.

The report documents the excellent quality of Sturgeon Lake and lists specific water quality criteria considered essential to protect the valuable fishery resources which are present. Application of these criteria and a consideration of the loading volume of the various waste constituents relative to the water volume and retention characteristics of Sturgeon Lake should ensure the future protection of this lake.

Additional copies of this report are available upon request.

Yours very truly,

J.H.Neil
Director

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PRELIMINARY

WATER QUALITY EVALUATION

of

STURGEON LAKE

DISTRICTS OF KENORA AND THUNDER BAY

1970

by

M. J. German, Regional Biologist

D. M. Pugh, Biologist's Assistant

Biology Branch
Division of Laboratories
ONTARIO WATER RESOURCES COMMISSION

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SUMMARY

During the months of August and October, 1970, staff of the Biology Branch undertook pre-operational surveys on Sturgeon Lake in the vicinity of a proposed mining development.

The findings of these surveys demonstrate the existing high quality of Sturgeon Lake water. In order to protect this excellent quality and ensure future protection of the lake's valuable sport fishery, treatment of wastes from the proposed mining and milling development should be adequate to satisfy the Commission's criteria for the protection of fish and wildlife, particularly those criteria which pertain to toxic substances and pH.

The report lists specific water quality criteria necessary to protect the aquatic life of Sturgeon Lake and the Bell River. The stringent nature of these criteria demonstrates the necessity for maximum possible reuse of process water. The water quality criteria cited in this report should be applied at a selected monitoring site and owing to the conservative nature of metals and dissolved solids, a consideration of the loading volume relative to the water volume and throughput of Sturgeon Lake is essential. These assessments will ensure the future protection of the receiving waters from accumulations of these constituents to sub-lethal levels affecting fish production.

INTRODUCTION

Investigations on Sturgeon Lake were carried out on August 11 - 13 and October 20, 1970, in order to document baseline chemical and biological conditions prior to the commencement of base-metal mining and milling operations by Mattabi Mines Limited on their holdings in the Sturgeon Lake area.

Findings of this report, as outlined herein, will provide the basis for evaluating subsequent changes in water quality should they occur as a result of the proposed mining development.

GENERAL DESCRIPTION OF THE STUDY AREA

Sturgeon Lake (Figure 1) is located approximately fifty miles northeast of Ignace via Highway 599, known as the Savant Lake Road.

The lake covers a surface area of approximately 55,000 acres and is separated roughly into two equal sections by the Sturgeon Narrows. The southern section known as the South Arm, lies for the most part within the District of Kenora. The northern section rests entirely within the District of Thunder Bay. During this investigation only the Southern Arm was sampled. It has a surface area of 30,000 acres and a maximum recorded depth of 162 feet.

Glaciation of the area has left Sturgeon Lake with an irregular shoreline, numerous islands and boulder shoals and a highly irregular drainage pattern. Normal drainage from the South Arm is primarily into the North Arm

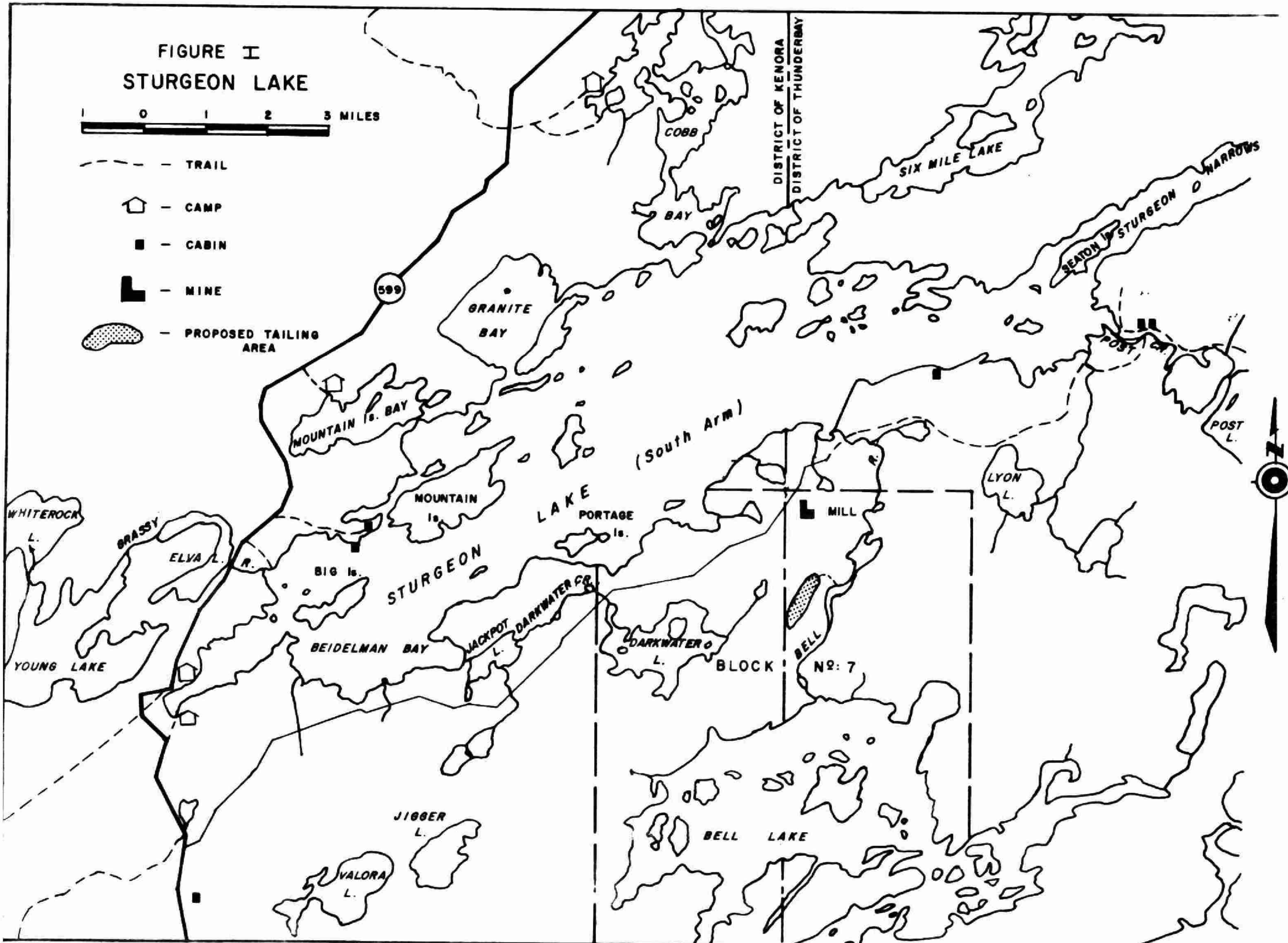
FIGURE I
STURGEON LAKE
1 0 1 2 3 MILES
TRAIL
CAMP
CABIN
MINE
PROPOSED TAILING AREA
DISTRICT OF KENORA
DISTRICT OF THUNDER BAY
COBB BAY
SIX MILE LAKE
STURGEON NARROWS
SEATON Is.
GRANITE BAY
POST CR.
POST L.
MOUNTAIN Is. BAY
(South Arm)
MOUNTAIN Is.
LAKE
PORTAGE Is.
LYON L.
MILL
WHITEROCK L.
GRASSY
ELVA L.
R.
BIG Is.
STURGEON
DARKWATER CR.
JACKPOT L.
BEIDELMAN BAY
DARKWATER L.
BLOCK Nº 7
BELL
YOUNG LAKE
JIGGER L.
VALORA L.
BELL LAKE
599

from whence it enters the Sturgeon River, Lac Seul and eventually the English River. During parts of the year, a flow also exists from the South Arm via the Grassy River into Elva, Young and Whiterock lakes to the English River.

Presently, Sturgeon Lake supports four tourist camps and several private cottages and is readily accessible for day-use recreation. The lake has pleasing natural features and provides excellent angling for northern pike, walleye and lake trout. The sport fishery of Sturgeon Lake is well developed. According to creel census and tourist outfitter's records, the annual angling pressure on Sturgeon Lake is estimated to be in the order of 13,000 to 25,000 rod-days per season and the angler harvest is estimated to be between 25 and 100 thousand pounds per season. (Department of Lands and Forests, unpublished). In addition to the sport fishery, the lake supports a commercial fishery for lake trout, whitefish, walleye and northern pike. The commercial fishery is operated on a quota system.

NATURE OF PROPOSED MINING DEVELOPMENT

During 1969, news circulated of a discovery by Mattagami Lake Mines Limited of large deposits of sulphide ores carrying high values of copper, zinc, lead and silver on freehold property of the Abitibi Power and Paper Company Limited in the vicinity of Sturgeon Lake, fifty miles northeast of Ignace. Significant discoveries of valuable mineralizations followed on adjacent claims and early in 1970, the OWRC became aware of plans by Mattagami and Abitibi to develop their holdings into a producing mine

under the control of a new company, Mattabi Mines Limited. This development in its early stages will involve open-pit mining and an initial milling rate of 3,000 to 4,000 tons per day. Underground mining will be practised during the latter stages of exploitation. It is believed that the mine will have a life expectancy of approximately fifteen years.

Wastewaters generated by mining and milling of sulphuritic ores are a serious source of contaminants, which if improperly handled, could have an undue influence on the ecology of Sturgeon Lake. One of the most serious potential effects of mining and milling wastes in the aquatic environment is the generation of acid resulting from the oxidation of iron sulphide. A simplified version of the reaction is as follows:

$$4FeS_2 + 15\ O_2 + 14H_2O \longrightarrow 4Fe(OH)_3 + 16H^+ + 8SO_4^{2-}$$

Hydrogen ions liberated by this reaction could lower the pH of the receiving water which in turn would seriously affect aquatic production. In addition to acid generation, mill wastes are characteristically high in dissolved solids, especially sulphates and heavy metals which could have harmful osmotic and/or toxic effects on aquatic organisms, including fish.

A further characteristic of the sulphide ore-body in the vicinity of Sturgeon Lake is its high mercury content, as verified by analyses of core samples by the Department of Mines. Mercury is a conservative metal which may not have a direct effect on aquatic biota but poses a serious health hazard to man, the terminal predator of the aquatic food chain.

The proposed method of handling wastes by Mattabi Mines Limited is to utilize a small unnamed lake in

the vicinity of the mill as a tailings area. An attempt will be made by the industry to recycle 100% of the tailings water back to the mill circuits. If this objective cannot be satisfied and some tailings decant has to be discharged to the adjacent Bell River, additional treatment facilities will be necessary to ensure compliance with OWRC objectives.

METHODS

The data reported herein was produced from two visits to the study area during 1970.

On August 11-13, thirteen locations on Sturgeon Lake were visited and their benthic communities sampled. These sampling sites are illustrated in Figure 2. Ten samples of the bottom fauna were taken at Station 4 and five samples secured from each of the other sites. All bottom fauna samples were taken with a 9 x 9 inch Ekman dredge.

On October 20, the lake was again visited and sampled at the seven locations shown in Figure 3 for purposes of securing water samples. Station 7, located on the Bell River, was sampled at a depth of two feet below the surface. Station 4, located in deep water off the mouth of the Bell River, was sampled at intervals of 20 feet from surface to bottom. At the remaining five stations only surface and bottom samples were taken.

On-the-spot measurements of water transparency, temperature and dissolved oxygen were made at each sampling site during the October survey. Water transparency was measured with an eight-inch Secchi disc. Temperature readings were made with a telethermometer. Dissolved oxygen concentrations were determined by means of the azide

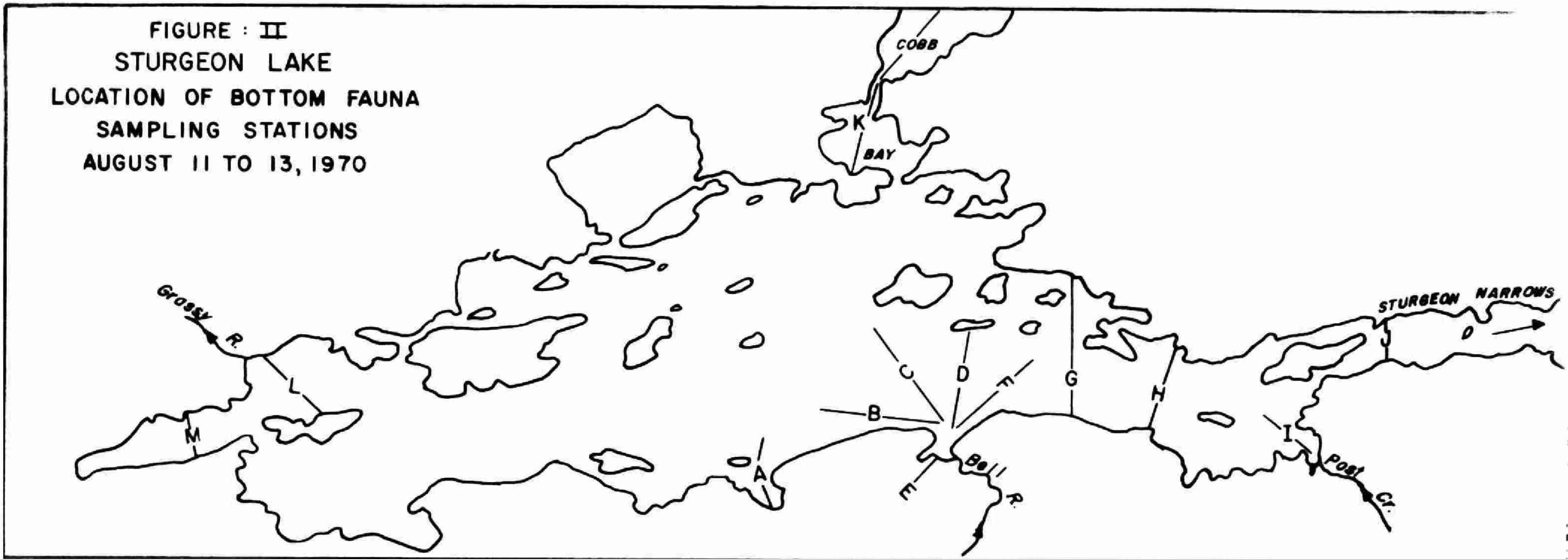

FIGURE : II
STURGEON LAKE
LOCATION OF BOTTOM FAUNA
SAMPLING STATIONS
AUGUST 11 TO 13, 1970

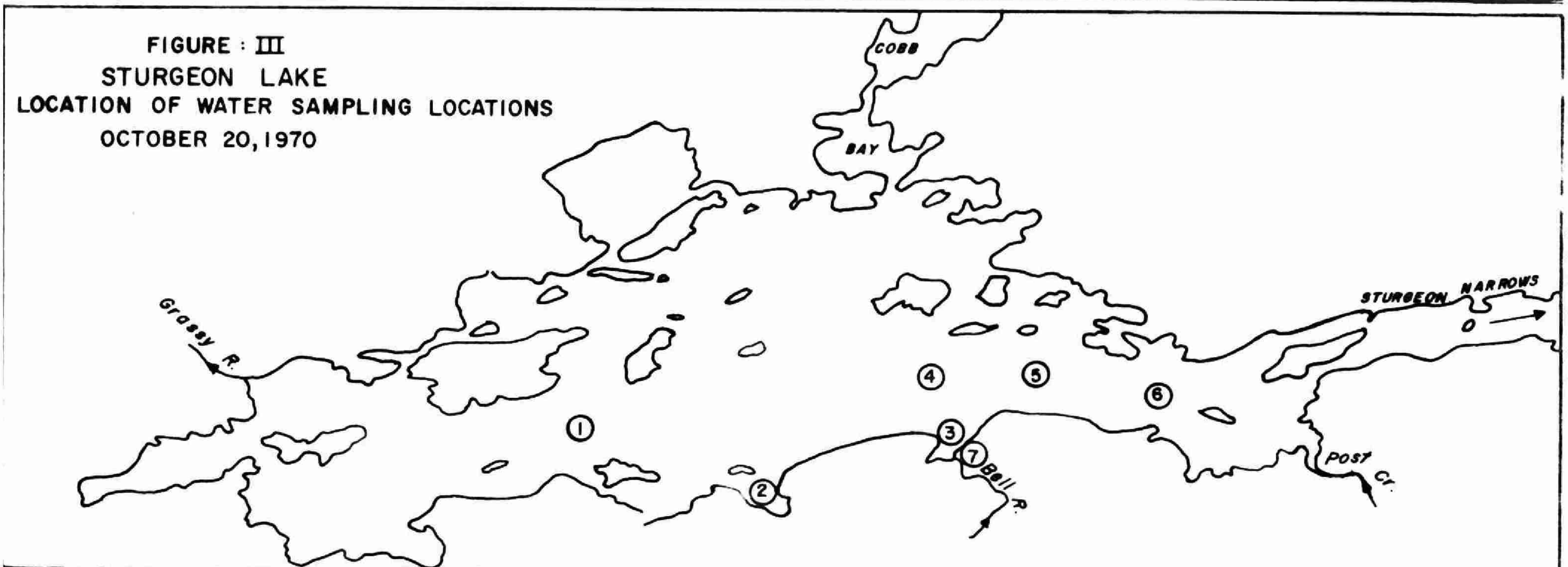

FIGURE : III
STURGEON LAKE
LOCATION OF WATER SAMPLING LOCATIONS
OCTOBER 20, 1970

modification of the Winkler test. Water samples for detailed chemical analyses were secured with a Kemmerer water sampler. Analyses for heavy metals were made on samples collected in plastic containers and preserved with nitric acid at the time of sampling. Metal determinations were completed at the main OWRC laboratory in Toronto. All other chemistry determinations were carried out on unpreserved samples shipped in glass containers to the OWRC laboratory at Thunder Bay.

A composite phytoplankton sample was taken from the euphotic zone at each of the sampling stations. The euphotic zone was determined as twice the Secchi disc reading. The phytoplankton samples were preserved with Lugol's iodine and were returned to the laboratory for microscopic identification and enumeration.

FINDINGS

Water Quality

Table 1 provides the temperature, transparency and dissolved oxygen data taken from Sturgeon Lake on October 20. By that date, both temperature and dissolved oxygen readings were constant throughout the water column, a condition common to lakes of the north temperate regions which undergo fall turnover or the process of destratification. The Secchi disc reading, which is a measure of water transparency, was approximately 15 feet on October 20. As a general rule, if one doubles the Secchi disc value, an estimate of the euphotic zone or zone of algal production is obtained.

In Sturgeon Lake, then, light penetration on October 20 was adequate to permit photosynthesis down to a depth of approximately thirty feet.

Table 2 gives the results of chemical analyses carried out in the laboratory on water samples taken from Sturgeon Lake on October 20. In general, these values show that Sturgeon Lake, like most lakes of the Precambrian Shield of Northwestern Ontario is poorly supplied with dissolved materials. The lake had a total dissolved solids content which ranged between 55 and 71 ppm, sulphate levels of 5 ppm or less and low levels (i.e. less than 0.05 ppm) of iron, zinc, copper, lead and manganese. Further, the waters of Sturgeon Lake had a low alkalinity (i.e. 20 to 28 ppm), no measurable acidity and a pH value on the alkaline side of neutrality (i.e. 7.6 to 7.8).

Bottom Fauna

Table 3 lists the results of bottom fauna sampling carried out on the South Arm of Sturgeon Lake during August, 1970. In general, these data show two discreet communities, one occupying the deep open-water expanse of the lake and the other living in the shallow-water bays. The open-water community is helpful in defining the trophic status of Sturgeon Lake since two of its member species, the amphipod *Pontoporeia affinis* and the opposum shrimp *Mysis relicta*, are indigenous to the clean-water oligotrophic and mesotrophic lakes of Northwestern Ontario. The shallow-water community contains a much more diverse association of macro-invertebrates, including forms such as the mayfly genus *Hexagenia* which is intolerant to changes in water quality. Therefore, periodic re-examination of the bottom fauna community at Station E will allow early warning of any adverse changes in water quality should they develop owing to the adjacent mining development.

RECOMMENDED CRITERIA

In June of 1970, the OWRC released its 'Guidelines and Criteria for Water Quality Management in Ontario'. In keeping with the intent of the policies contained therein, the development of mining operations in the vicinity of Sturgeon Lake must be consistent with the protection of water quality suitable for multiple use.

Past experience has clearly indicated the extreme vulnerability of poorly buffered waters to reduced pH, increases in toxic metals concentrations and large increases in dissolved solids content. The failure of initial pH adjustment to prevent permanent mitigation of pH effects has underlined the necessity to ensure complete oxidation of sulphuritic materials prior to discharge. In a number of situations, acid generation in the receiving water has resulted from the continued oxidation of sulphides and other compounds present in mining wastes.

Adequate maintenance of the existing high quality in Sturgeon Lake necessitates application of the following water quality criteria at an appropriate monitoring location:

Criteria	Value (calculated 'no effect' levels)
pH*	6.5 to 8.5 (precise value to be determined)
Copper	.0015 mg/l
Iron	0.5 mg/l
Lead	.02 mg/l
Manganese	1 mg/l
Nickel	.08 mg/l
Zinc	.02 mg/l
Cadmium	No discharge acceptable in excess of 0.005 mg/l
Mercury	No discharge acceptable in excess of 0.005 mg/l

*Adequate controls of acidic discharges or substances having latent potential to cause subsequent pH depression in the receiving water system must be maintained.

The aforementioned criteria are calculated 'no effect' levels based on extrapolation of available literature dealing with experimental evaluations of acute and, in some cases, sub-lethal effects of the various wastes on aquatic organisms.

The values cited for zinc and copper, .02 mg/l and .0015 mg/l, respectively are derived from a generous accumulation of acute toxicity results under well-defined conditions and supported by experimental assessments of sub-lethal effects including reproductive effects and appropriate measures of physiological or behavioral alterations. Pertinent literature supporting the criteria for zinc and copper include recent work reported by Brungs (1969), Arthur (1970), Mount (1968), Saunders et. al.(1967) and Brown et. al. (1970).

The values cited for iron, lead, manganese and nickel are based on results of acute toxicity tests but so far sub-lethal effects have not been adequately defined. An appropriate safety factor has thus been applied and incorporated into the values assigned, based on a consideration of factors such as stability and synergistic potential of the element under consideration. Reference to studies reported by Brown et. al. (1970) dealing with the acute toxicity of nickel, and Water Quality Criteria (1963) which provides a summary of acute toxicity figures for manganese, iron and lead provide the pertinent sources from which the values in the above table were derived.

Mercury and cadmium are metals which are known to accumulate through the aquatic food chain and which may be problematical where man is the terminal predator. The potential health hazard associated with these two metals necessitates the stringent values given in the foregoing table.

In order to meet these somewhat stringent requirements considering the poor buffering capacity of Sturgeon Lake, adequate treatment of wastes associated with extracting and milling processes should be provided to ensure that the waste effluent remains within the aforementioned limits.

Since the Bell River drains an area of sulphide ores with a high degree of mineralization, the metals content of the receiving water under natural conditions might well exceed the values given in the foregoing table. As the aforementioned criteria represent the 'no effect' concentrations (as established by toxicological research) it is especially important that metal constituents in the mine waste discharge do not exceed existing concentrations in the receiving water system. This necessity is heightened by an imperative need to avoid a continuous elevation of metals in downstream waters.

The stringent criteria for cadmium and mercury are necessary since both metals are known to accumulate through the aquatic food chain and both metals are known to have harmful effects if consumed in quantity by man.

It is likely that further mining development will occur on adjacent claims. Since heavy metals are conservative in nature and might become concentrated in Sturgeon Lake should a discharge be unavoidable, future monitoring of heavy metals in the water and sediments of Sturgeon Lake will be essential.

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Saunders, R. L. and Sprague, J. B. 1967. Effects of Copper-Zinc Mining Pollution on a Spawning Migration of Atlantic Salmon Salmo solar. Water Research 1(6):419-432.

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TABLE 1

Physico-Chemical Data, Sturgeon Lake, October 20, 1970

Station	Sample Depth/Ft.	Secchi Disc./ft.	Temperature °F	Dissolved Oxygen PPM	Dissolved Oxygen % Saturation
1	0	15	46	9	77
	100		46	8	69
2	0	15	47	8	70
	25		47	9	78
3	0	15	45	9	76
	15		47	9	78
4	0	14	46	10	86
	20		46	10	86
	40		46	9	77
	60		46	9	77
	80		46	9	77
	100		46	9	77
5	0	15	45	9	76
	85		45	9	76
6	0	12	45	9	76
	45		45	9	76
7	0	Bottom	43	9	74

T A B L E 2

Chemical Determinations Made on Water Samples
Collected from Sturgeon Lake, October 20, 1970

Parameter	Station	1		2		3		4					
	Depth	0	100	0	25	0	15	0	20	40	60	80	100
Total Solids		66	60	76	68	66	62	58	64	60	58	62	60
Susp. Solids		5	5	5	5	5	5	5	5	5	5	5	5
Diss. Solids		61	55	71	63	61	57	53	59	55	53	57	55
Conductivity		55	55	55	59	55	55	56	55	55	55	57	55
Turbidity		0.5	0.6	1.4	5.2	1.0	0.6	0.7	0.7	0.7	1.0	0.6	4.0
Sulphate		4	3	3	5	3	4	3	3	3	3	3	3
Alkalinity		22	28	20	24	22	22	22	22	20	22	22	20
Acidity		0	0	0	0	0	0	0	0	0	0	0	0
Hardness		26	28	26	26	26	24	28	26	26	24	24	24
pH		7.8	7.7	7.8	7.7	7.7	7.7	7.7	7.8	7.8	7.7	7.6	7.6
Iron*		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Zinc*		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Copper*		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Lead*		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Manganese*		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Silica								1.3	1.3	1.3	1.3	1.3	1.3
Cyanide								0.00	0.00	0.00	0.00	0.00	0.00
Sodium		23	2	5	2	2	3	1	1	1	1	2	13
Potassium		0.6	0.5	0.7	0.6	0.6	0.6	0.6	0.5	0.5	0.5	0.5	0.6
Calcium		9	10	10	9	9	9	9	9	9	9	10	10
Magnesium		1	1	1	1	1	1	1	1	1	1	1	1

Note: All values except pH and Turbidity are expressed as parts per million.

* The value 0.0 signifies a concentration of less than 0.05 ppm.

Table 2 - continued

Parameter	Station Depth	5		6		7
		0	85	0	45	Bell River
Total Solids		66	62	60	74	70
Susp. Solids		5	5	5	5	5
Diss. Solids		61	57	55	69	65
Conductivity		54	53	57	56	42
Turbidity		1.1	0.8	1.3	0.7	0.7
Sulphate		3	4	5	<3	6
Alkalinity		24	22	22	22	14
Acidity		0	0	0	0	0
Hardness		24	28	26	26	22
pH		7.7	7.7	7.7	7.6	7.6
Iron		0.0	0.0	0.0	0.0	0.0
Zinc		0.0	0.0	0.0	0.0	0.0
Copper		0.0	0.0	0.0	0.0	0.0
Lead		0.0	0.0	0.0	0.0	0.0
Manganese		0.0	0.0	0.0	0.0	0.0
Silica						
Cyanide						
Sodium		1	1	1	1	1
Potassium		0.5	0.5	0.5	0.5	0.6
Calcium		10	10	10	10	10
Magnesium		1	1	1	1	1

Note: All values except pH and Turbidity are expressed as parts per million

TABLE 3

Bottom Fauna Data Secured From Thirteen Locations on Sturgeon Lake

August, 1970

Results Expressed in Numbers of Organisms Per Square Foot

Taxa	Station	Sturgeon Lake												
		A	B	C	D	E	F	G	H	I	J	K	L	M
MAYFLY														
Ephemera													1	
Hexagenia		<1	1	<1		3	<1		1	1	1		2	
CADDISFLY														
Phylocentropus						<1	<1			<1				
ALDERFLY														
Sialis		<1				<1				2				
HORSEFLY														
Crysops						<1								
DIPTERA														
Tendeipedidae		3	1	3	2	5	5	2	5	8	3	7	2	1
Heleinae						<1			<1	<1				
Chaoborus		<1								1		3		<1
OPOSSUM SHRIMP														
Mysis relicta				1	<1		2	1						
AMPHIPOD														
Hyalella azeteca		<1				<1								
Pontoponeia affinis		3	3	17	14	<1		54	41	<1	30	44	4	9
MULLUSCA														
Clam														
Pisidium		1						2	<1			4		
Snail														
Amnicola		<1												
LEECH														
Helobdella stagnalis		<1												
MITES														
Unident		<1			<1				<1					
WORMS														
Oligochaeta			3	2		<1		2	4		<1	<1		1
No. of Taxa		10	4	5	4	9	4	5	7	7	4	5	4	4
Average Depth of Station		12	49	58	36	9	34	76	38	10	35	58	18	43

DATE DUE
